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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION  
NATIONAL WEATHER SERVICE  
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE 247

The Significance of Vertical Resolution for Predicting the  
President's Day Snowstorm of 1979

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This is an unreviewed manuscript, primarily  
intended for informal exchange of information  
among NMC staff members.

## Introduction

In February 1979, an east-coast cyclone developed which caused a very large snowfall to occur in the mid-Atlantic states. This impressive storm, called the President's Day storm, has been documented by Bosart (1981), and has been the basis for a number of numerical experiments with NMC prediction models. The storm was employed by Newell (1981) in his study of the impact of sensible and latent heat transfer from the sea upon the performance of an experimental ten-layer version of the LFM model, and by Deaven in his evaluation of a new moist convection parameterization system. Recently we completed a series of numerical experiments using a variety of versions of the LFM model in order to isolate the relative importance of resolution and physical process parameterizations in the prediction of this storm. It is the objective of this paper to document the results obtained and to propose a line of development which seems to flow from these results.

At the time (18-20 Feb 1979) of occurrence of the President's Day storm, the NMC was using the LFM II model described by Deaven and Newell (1981), except that the precipitation parameterization system was still that described by Gerrity (1976). The performance of the operational forecast was critiqued by Bosart who rightly observed that the forecast was insufficiently accurate to provide clear guidance that a major snowfall was to be anticipated.

Bosart suggested that this relatively unsatisfactory performance could be attributed to certain deficiencies in the then-operational model; viz,

1. inadequate vertical resolution
2. omission of significant level data in analysis
3. improper boundary layer physics
4. inadequate simulation of bulk effects of convective-scale processes.

The experiments reported here address to varying degrees the deficiencies 1, 3 and 4. Significant-level data are not presently available at NMC in time for use in the objective analysis code. Future plans do call for NMC to run a high-resolution forecast model with a later starting time; this will permit the acquisition and use of significant level data in the objective analysis codes.

## 2. The Storm

Figure 1 taken from Bosart (1981), shows the synoptic evolution of the east coast cyclone during the period 1200 GMT 18 Feb. 79 to 1200 GMT 19 Feb. 79. In figure 2, also taken from Bosart's paper, the six-hourly precipitation amounts are shown. The lower-right figure covers the six hour period 1200-1800 GMT 19 Feb. 79, during which the snowfall intensity was especially large in the Washington DC area.

In figure 3 we show the analyzed sea-surface temperature field used in the operational NMC forecasts. The figure includes the difference between the analysis and the RAND climatological norm for February. Over a long strip, parallel to the east coast, the analysis shows sea surface temperatures to be about  $3^{\circ}\text{C}$  colder than normal. Positive departures from climatology appear only off the coasts of New England and Florida. This depiction is significantly at variance with the analysis shown by Bosart in his figure 20. That depiction shows sea surface temperature of  $24^{\circ}\text{C}$  off the Carolina coast which exceeds the RAND climatological norm by two or more degrees.

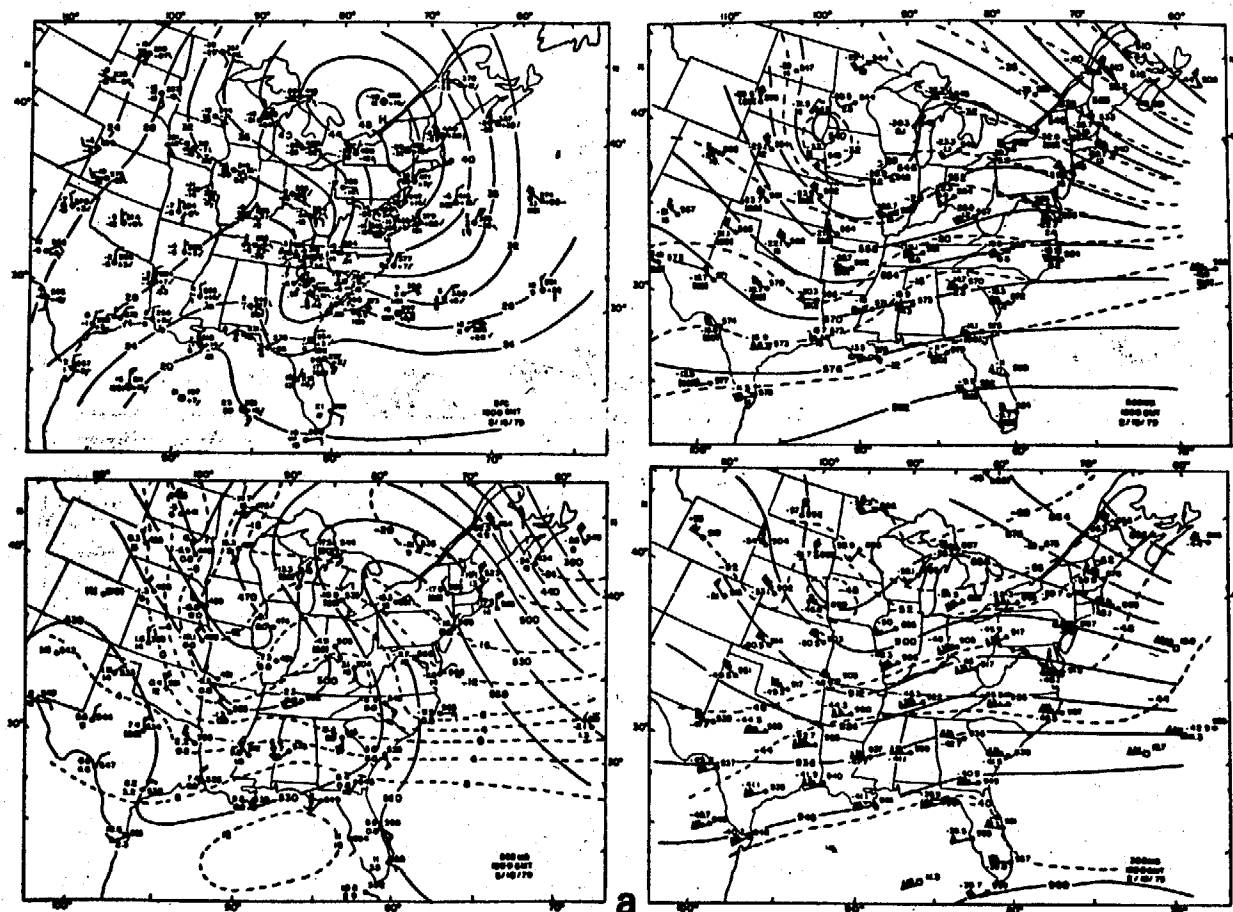


FIG. 1. Surface, 850, 500 and 300 mb maps for 1200, 0000 and 1200 GMT 18-19 February 1979. Conventional plotting and analysis scheme. Winds in  $\text{m s}^{-1}$  [pennant =  $25 \text{ m s}^{-1}$ , full (half) barb =  $5$  ( $2.5$ )  $\text{m s}^{-1}$ ], temperature in  $^{\circ}\text{C}$ . Heights, surface pressures and isotherms indicated by solid and dashed lines, respectively. Solid station circles above the surface indicate a temperature-dew point temperature spread  $\leq 5^{\circ}\text{C}$ . Aircraft observations are entered on the 300 mb charts.

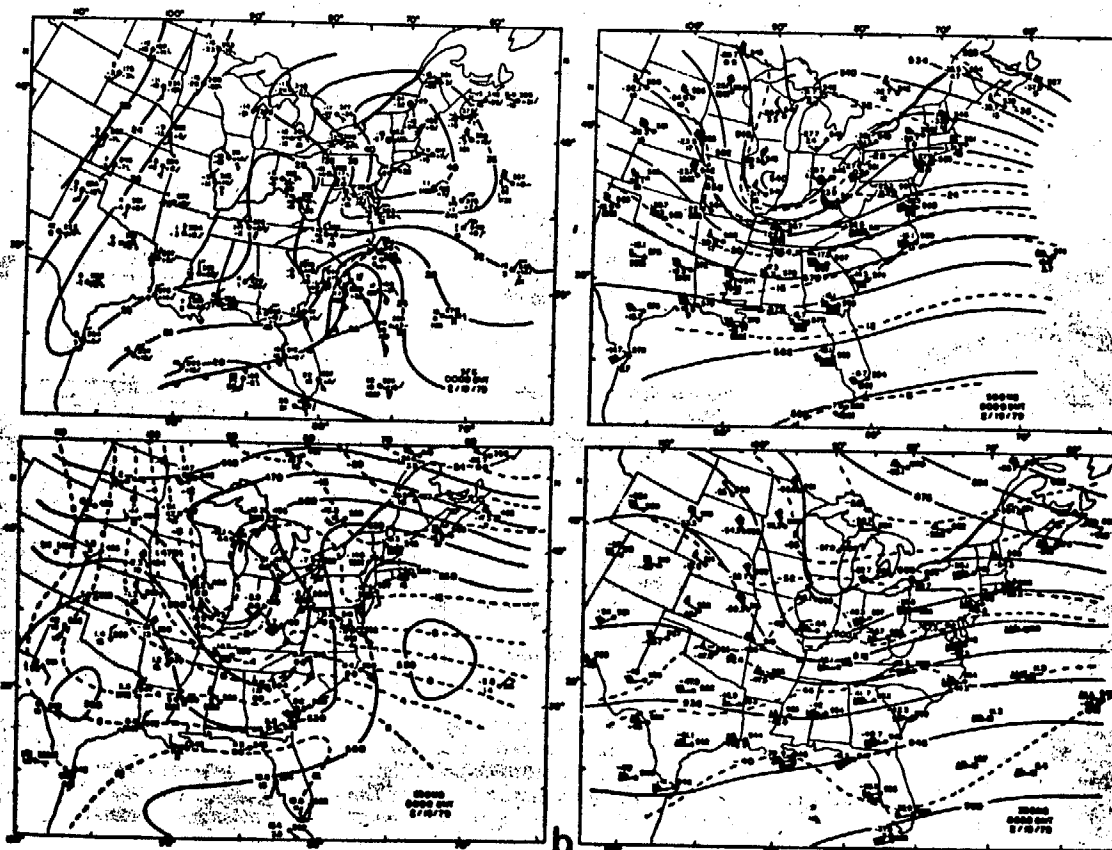
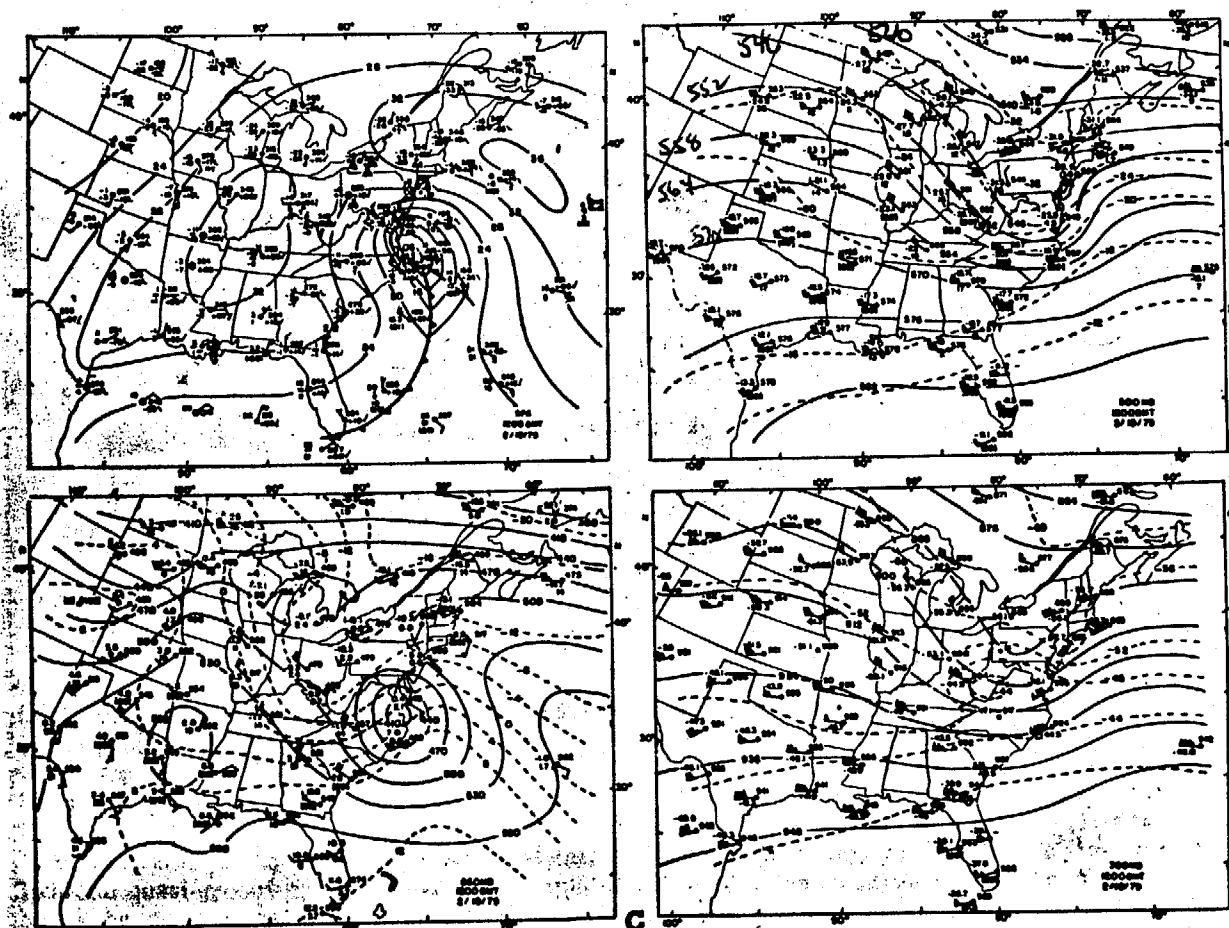


FIG. 1. (Continued)



1200 GMT 2/19/79

FIG. 1. (Continued)

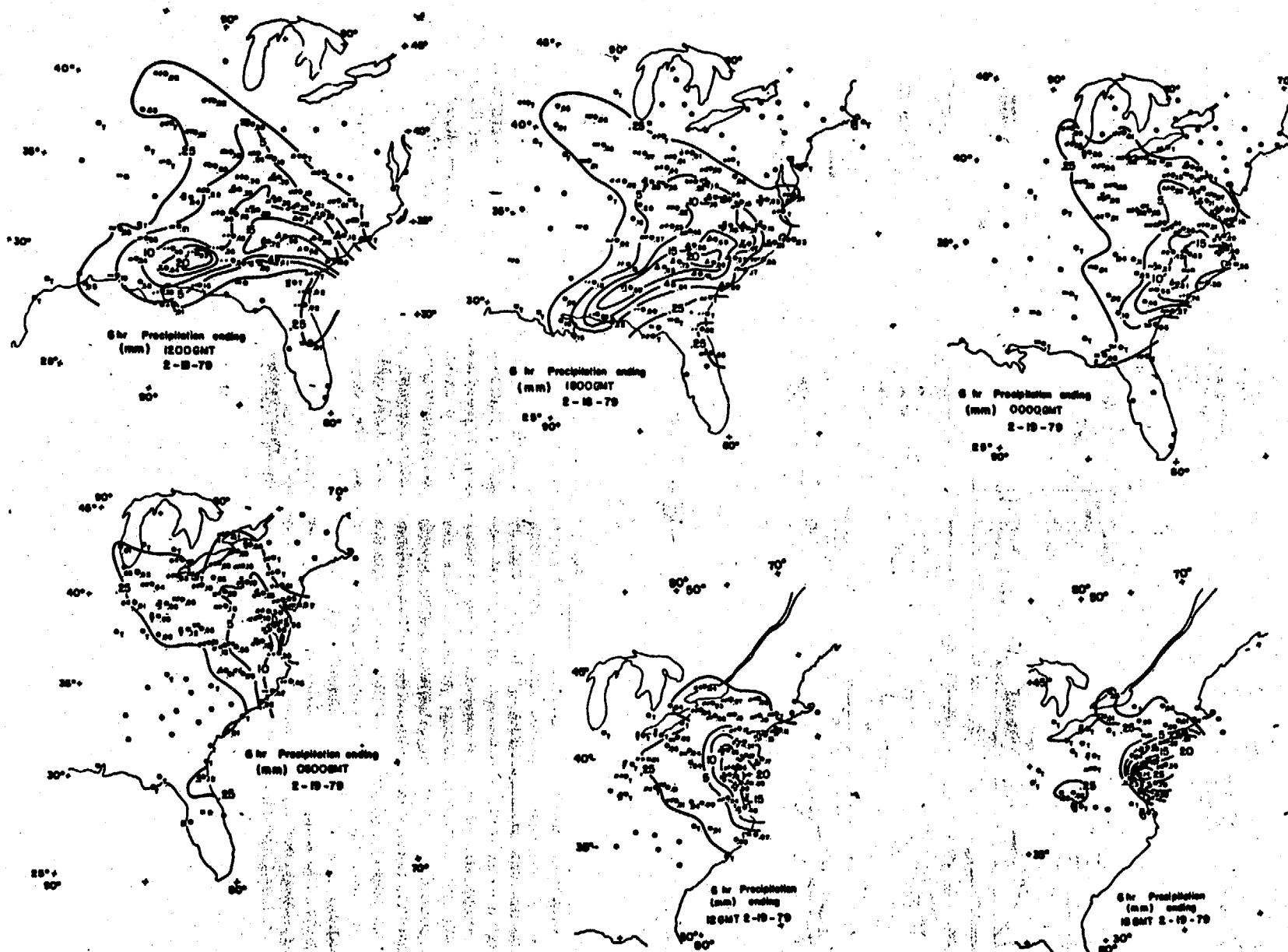
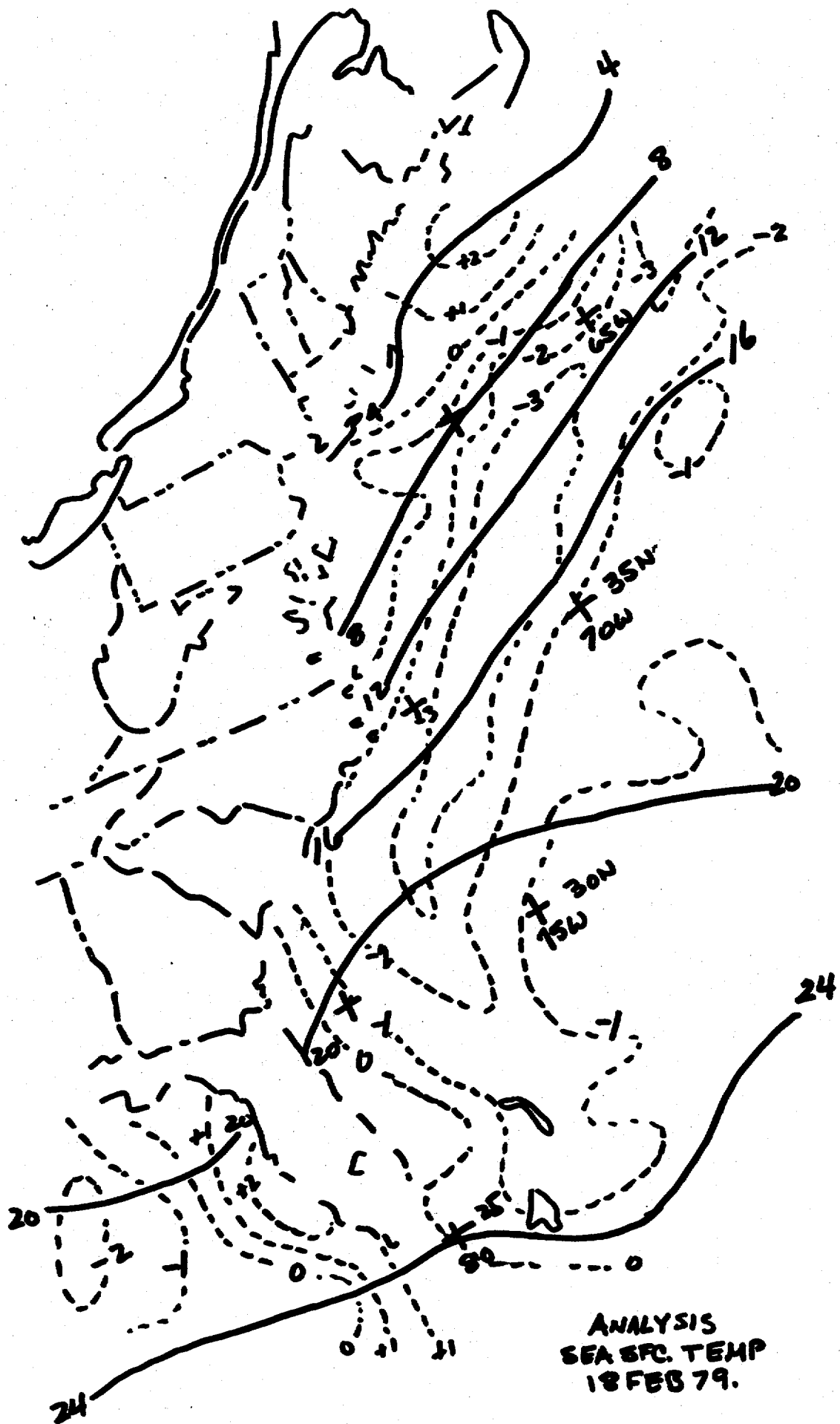


FIG. 2. Accumulated 6 h precipitation and present weather analysis for indicated times. Analyses in millimeters; raw observations for some stations plotted in hundredths of an inch (1 mm = 0.04 inch).



ANALYSIS  
SEA SFC. TEMP  
18 FEB 79.

FIG 3

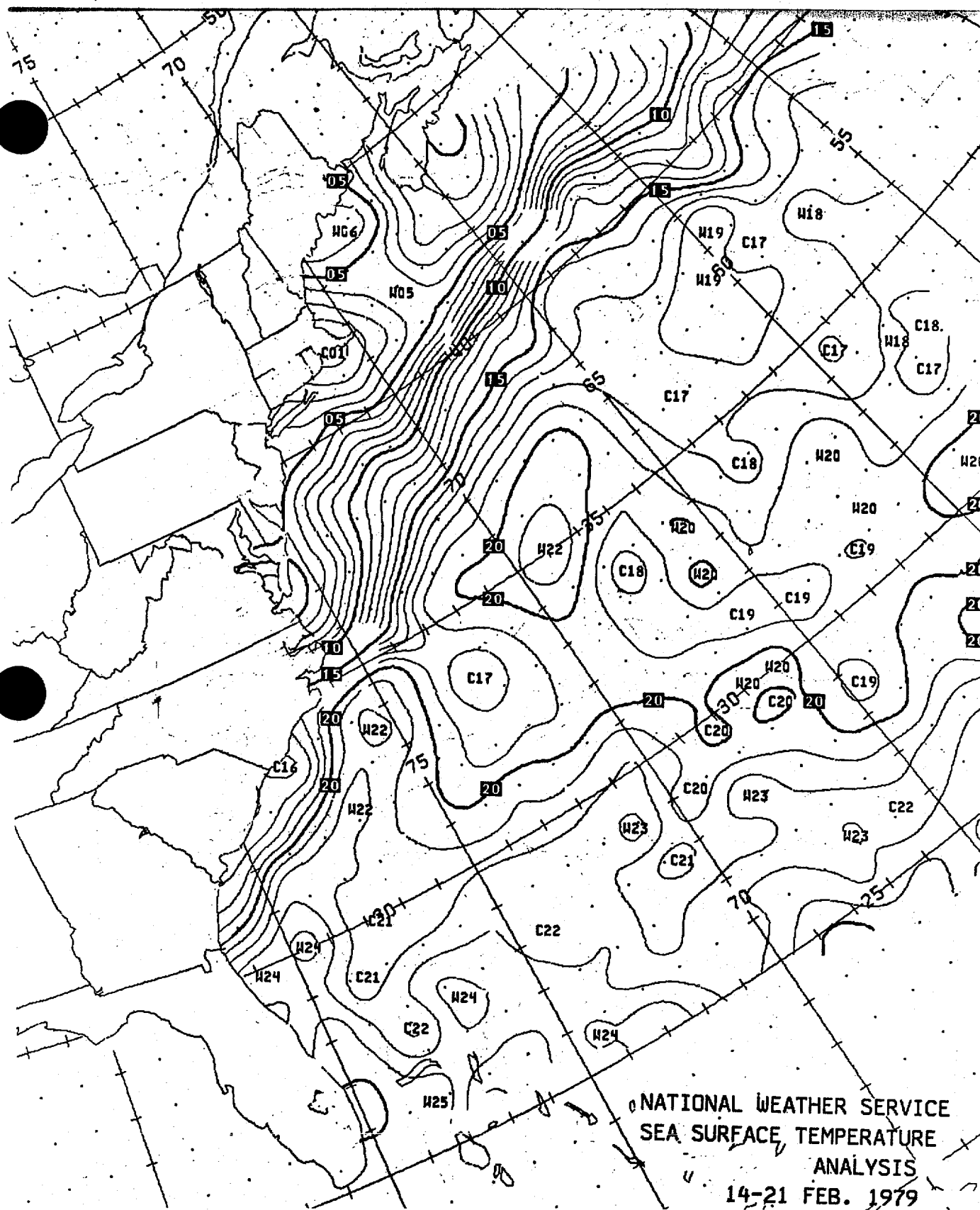


FIG. 4

In figure 4 is shown an experimental regional analysis of sea surface temperature produced by NMC's Ocean Services Group for the period 14-21 February 1979. The axis of warmest water runs from 80°W, 30°N to 75°W 34°N. The sea surface temperature in the warm-water streak is about 22.5°C except in its southwestern section where it reaches 24°C. This objective analysis is similar to that presented by Bosart.

We are forced to conclude that the parameterization of air-sea interaction used in the experiments discussed subsequently is not as realistic as one would wish. By comparison of forecasts based upon 'climatological' and 'analyzed' sea surface temperature we may be able to clarify the magnitude of the effect. Ideally, we would like to perform an integration using the more realistic temperatures shown by both Bosart and the NMC Ocean Services Group. Such an experiment will be attempted at a later date.

Bosart presented a detailed description of the evolution of the coastal cyclone. He shows evidence for the development of a coastal front along which a cyclonic circulation develops. The cyclone appears to move over land just west of Cape Hatteras at 0900 GMT 19 Feb 79. At 1200 GMT 19 Feb 79, the storm is located just east of the Delmarva peninsula with central pressure less than 1008 mbs.

In subsequent discussion, we will emphasize the 24 hr forecast position of the storm produced in the several experiments. We have examined neither the six-hourly storm positions, nor the detailed structure of the forecasts. If we are able to repeat the experiment with corrected sea surface temperature fields, a detailed diagnosis of the forecast fields may be warranted.

### Operational Model Capability

In this section we discuss the forecasts produced by the operational version of the LFM used at the time the storm occurred and the forecast produced by the presently operational version of the LFM model. The same initial analysis fields were used in both forecasts. The presently operational version of the LFM uses a coarser grid mesh (190.5 km @ 60°N) than the originally operational version (127 km @ 60°N), but it employs more accurate numerical approximations. The presently operational LFM also employs improved formulations of convection and sea-air interactions.

The 12 hourly precipitation and mean sea-level pressure forecasts are shown in figure 5. The map on the left in each panel is obtained from the presently operational version of the LFM, while that on the right is the forecast from the LFM which was operational at the time of the storm occurrence.

Comparison of these forecasts with each other and with Bosart's analysis of the storm shows that the presently operational version of the LFM produces a forecast that is no better than the forecasts made back in February of 1979.

To clarify the possible impact of the poor sea surface temperature analysis available to the model in 1979, we have made an experimental forecast using climatological sea surface temperatures which appear to have been somewhat more accurate. We also introduced into this experiment the new convection parameterization. The results through 36 hours are shown in figure 6.

We notice no improvement in the forecast. The results in this run appear somewhat more like those obtained with the presently operational LFM, even though the result came from a model with higher horizontal

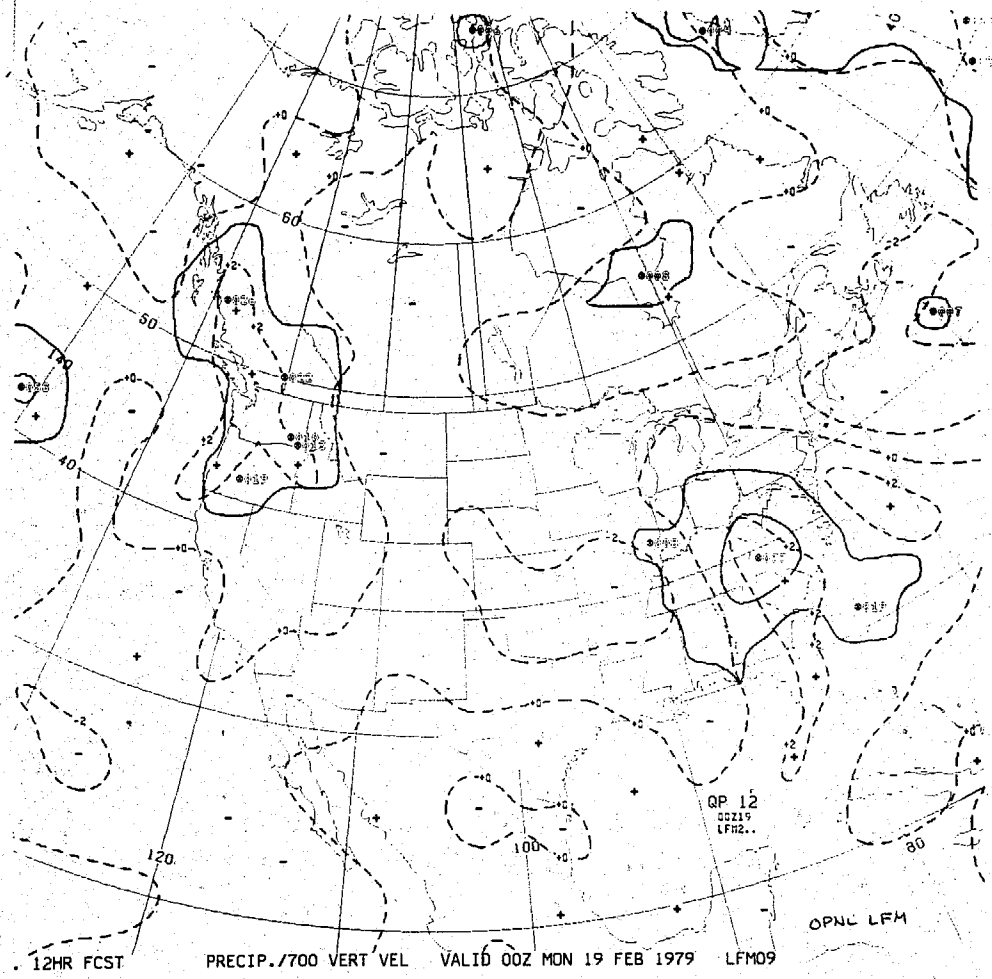
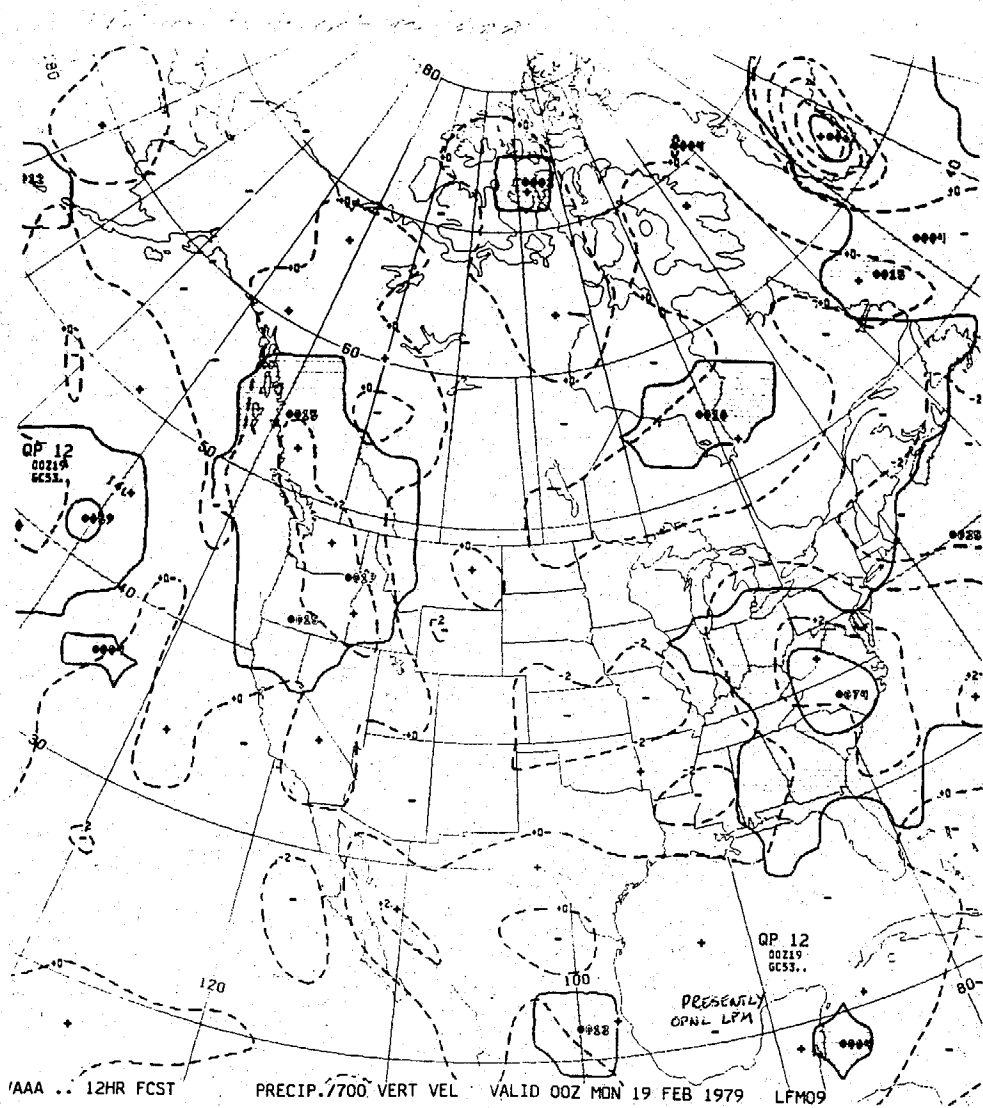


Fig 5 A.



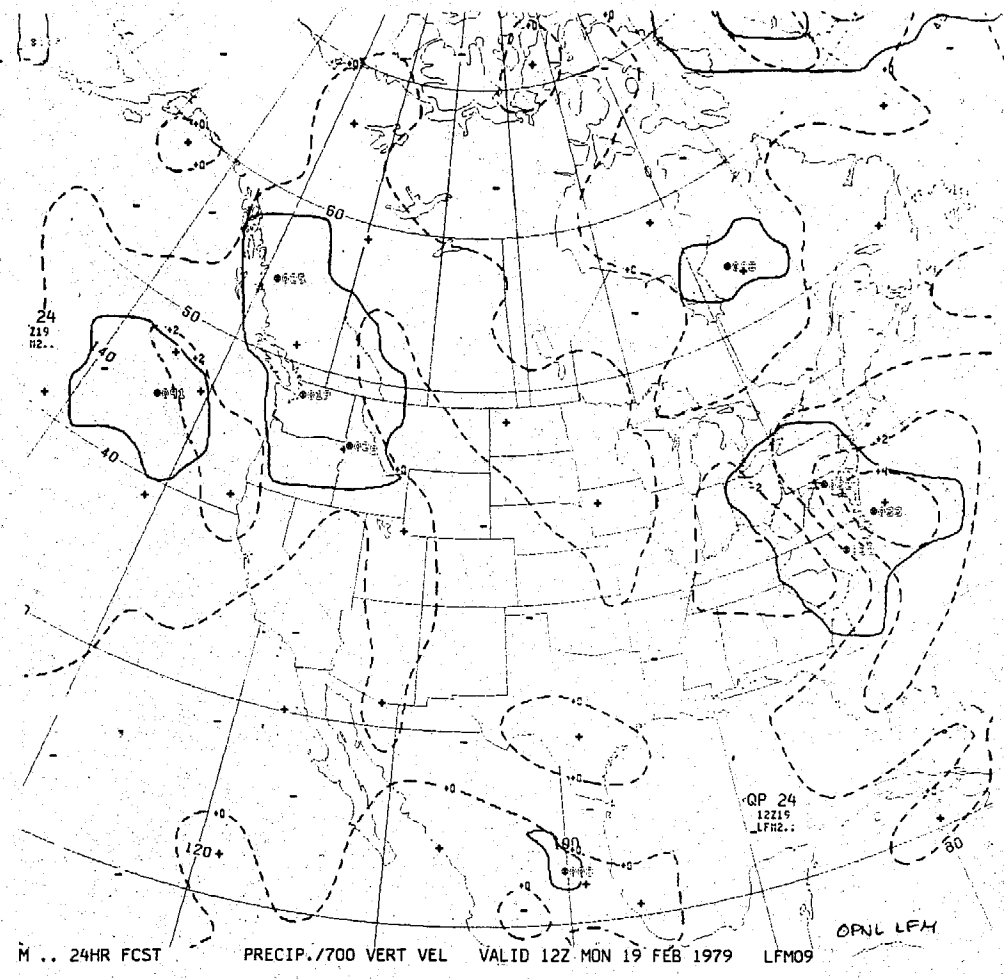
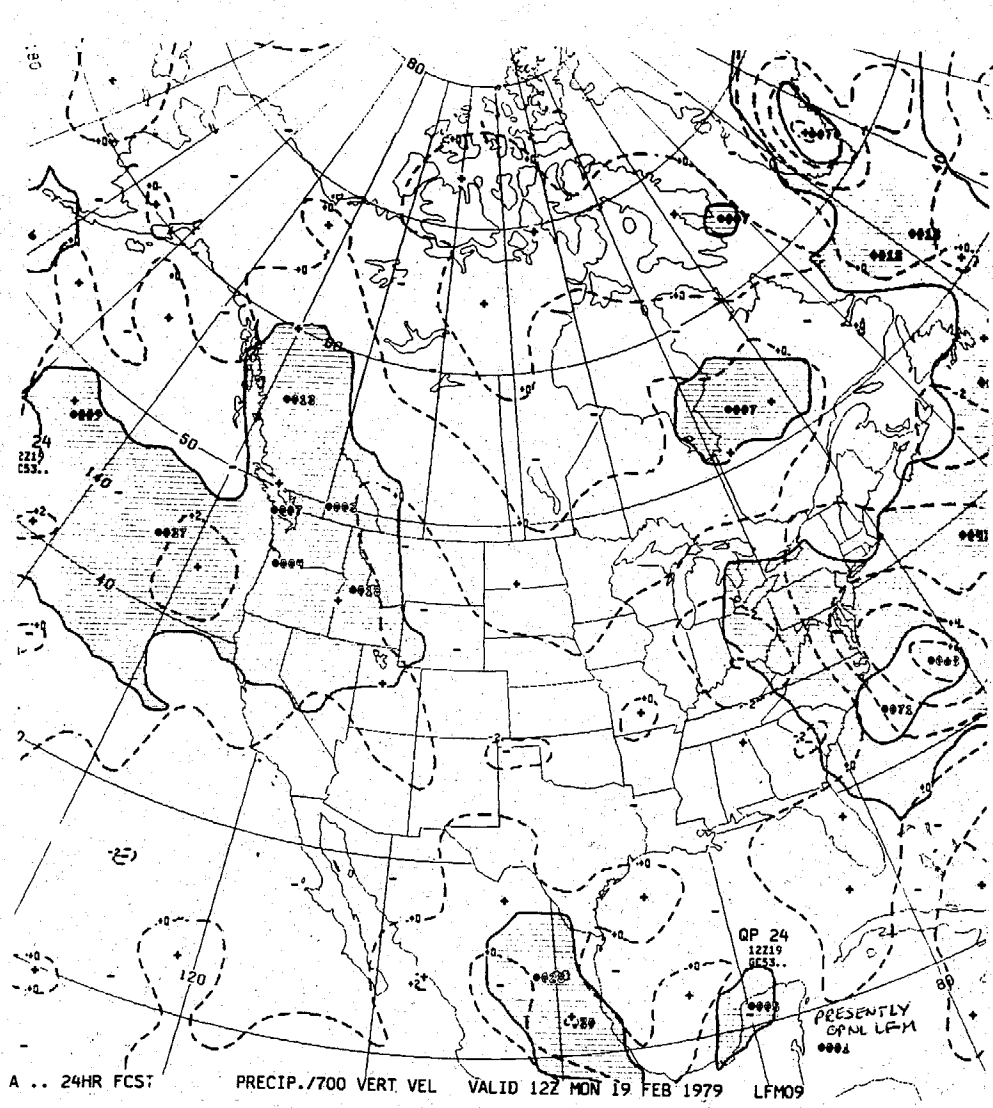


Fig 5c

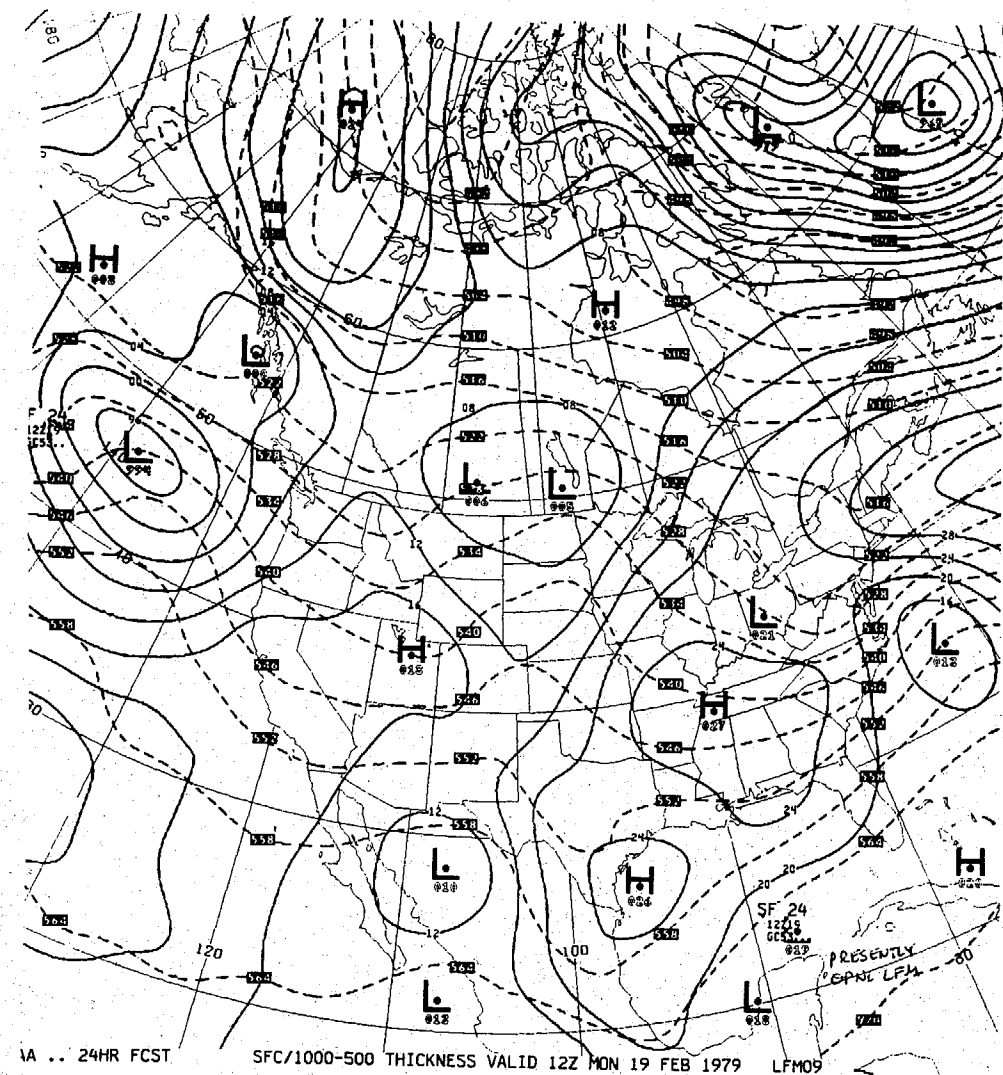
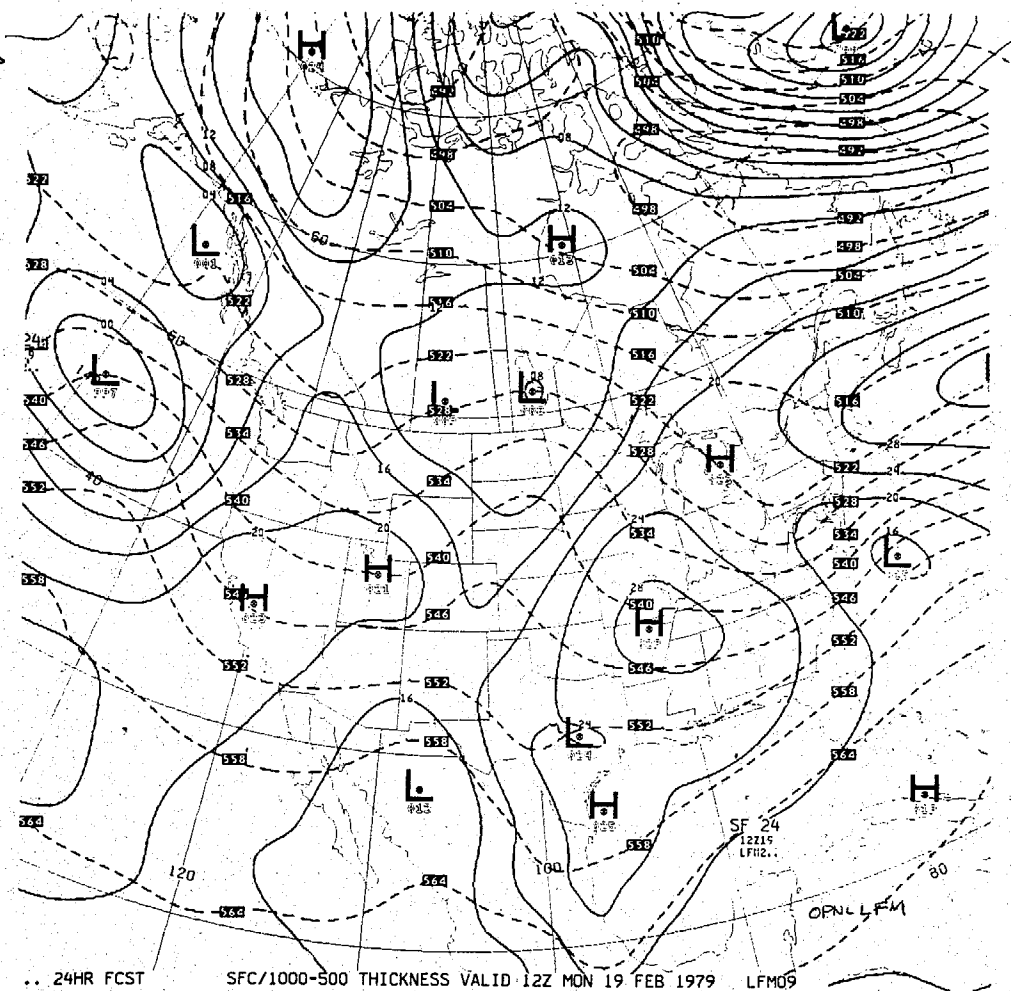


Fig 5D



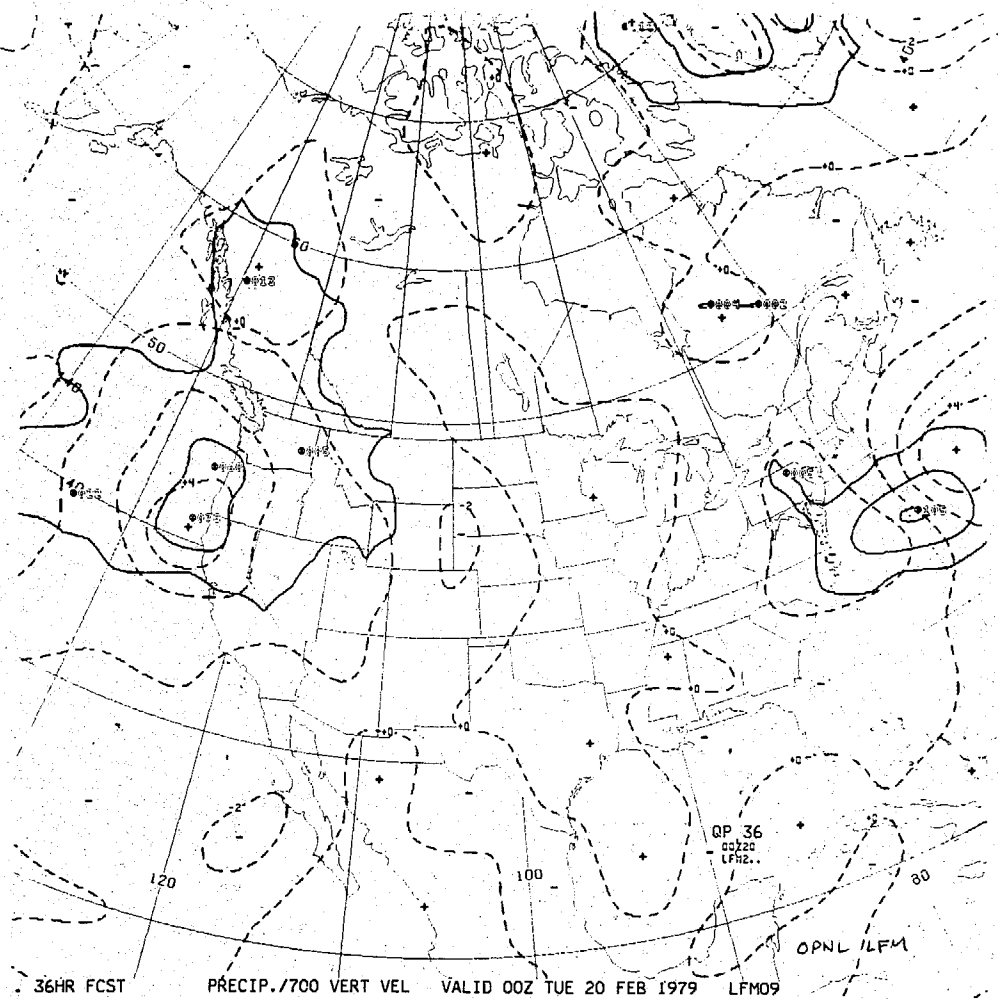
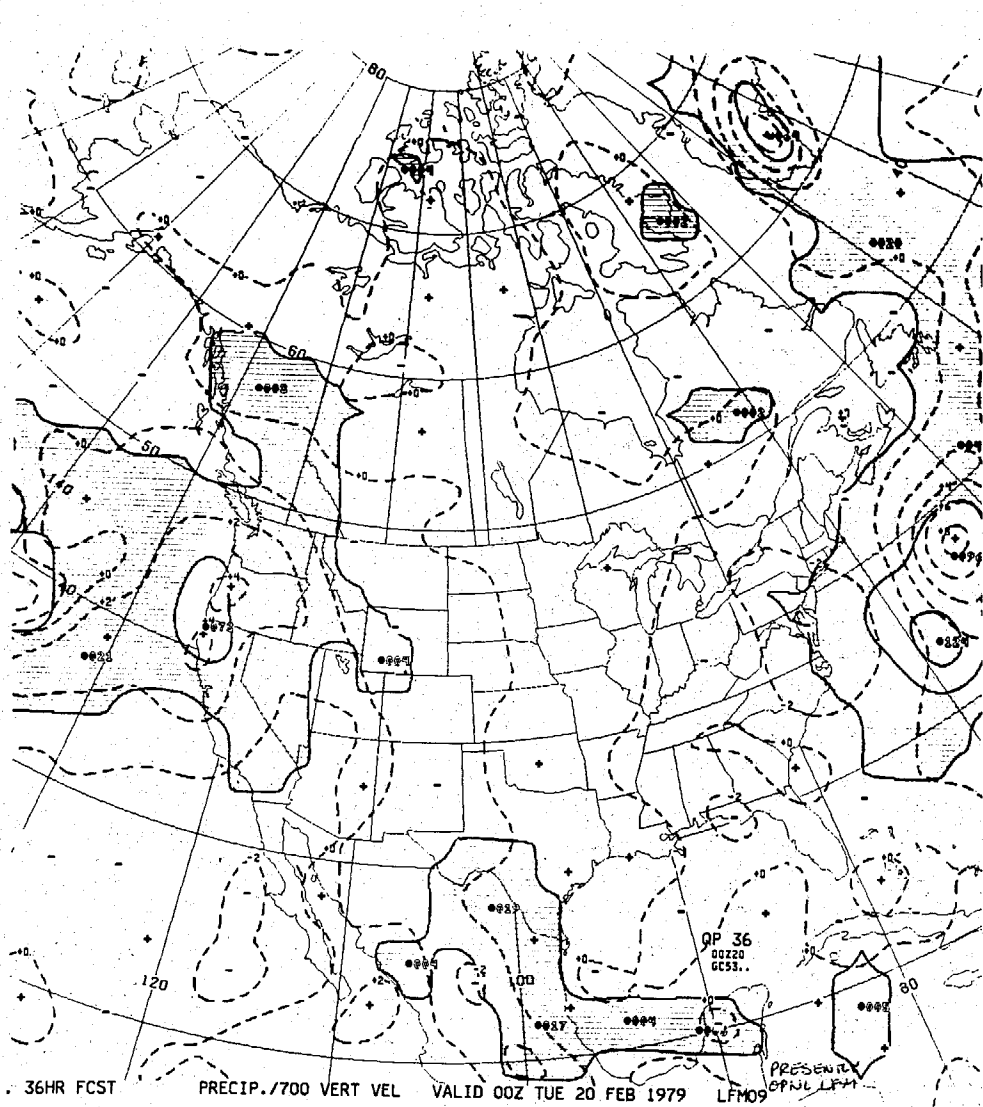


Fig SE

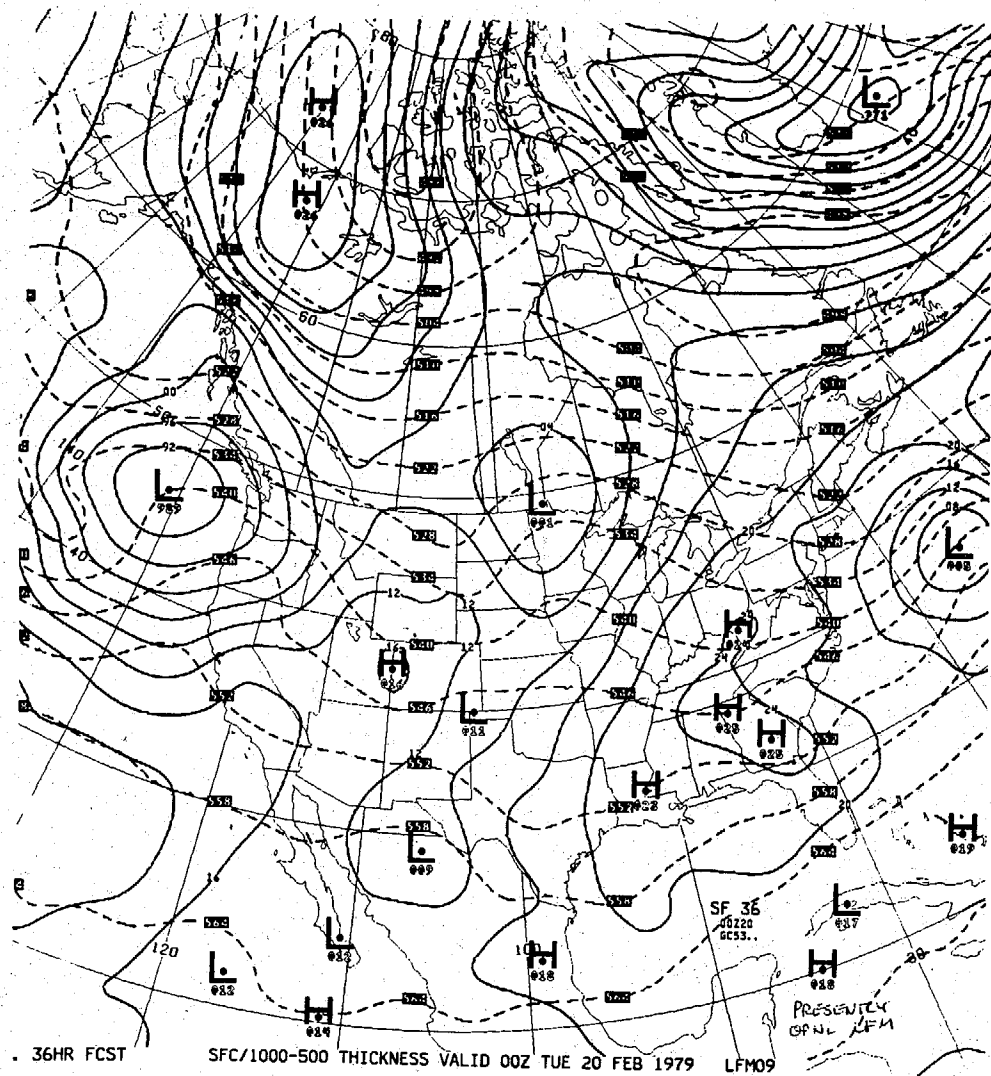
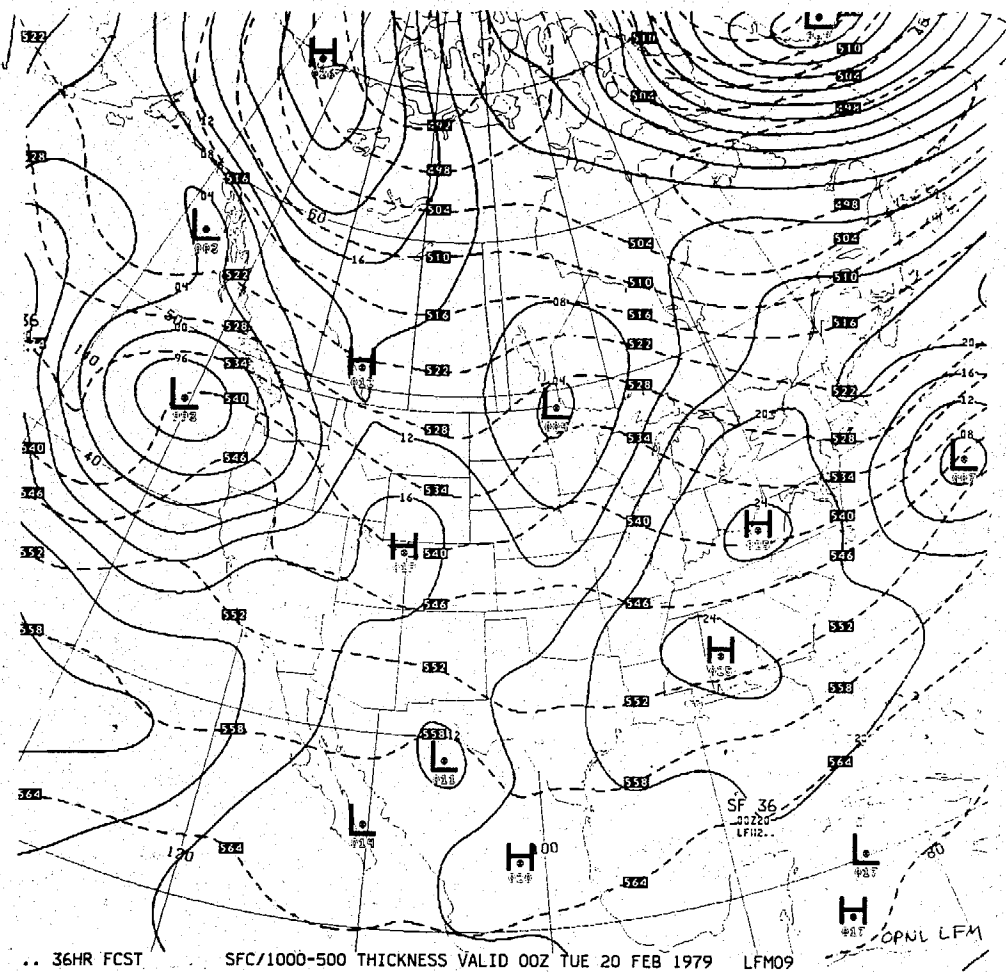


Fig 5F



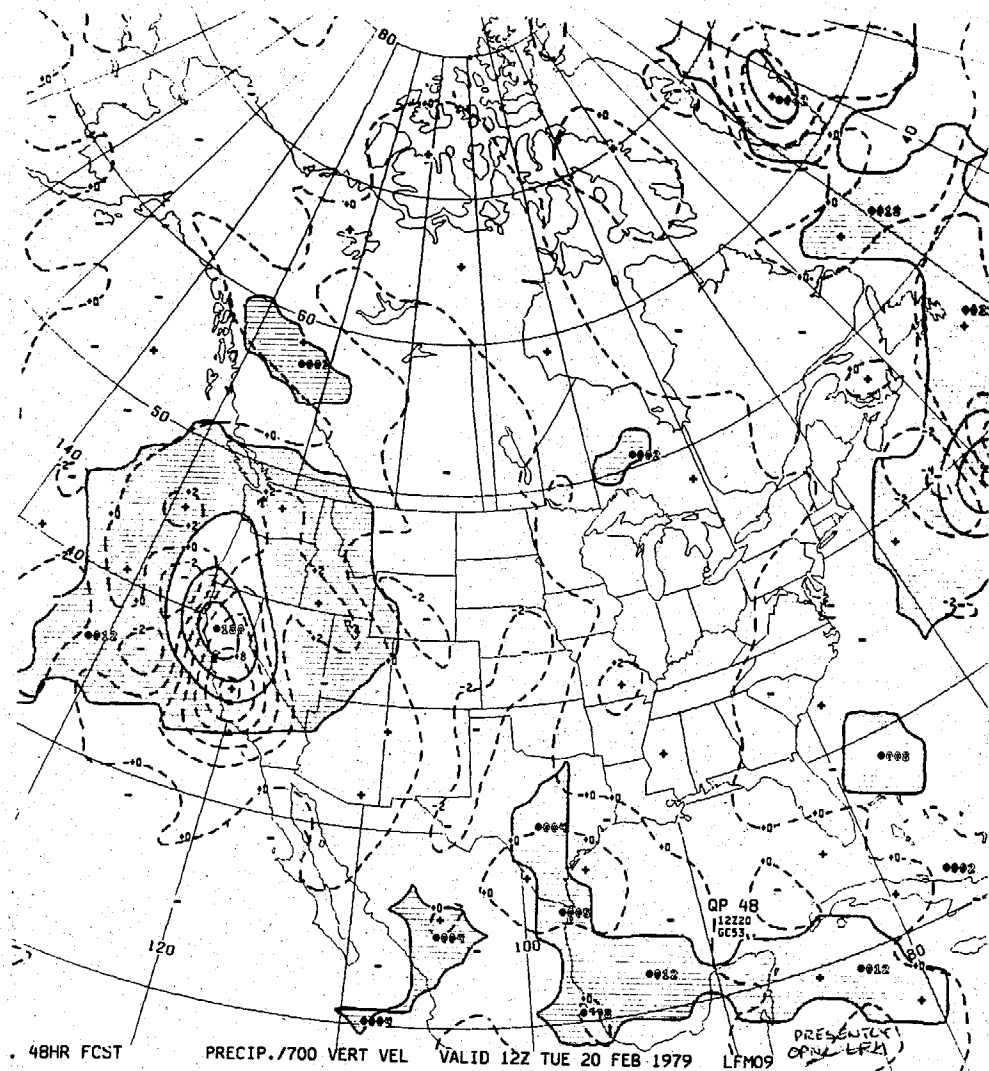
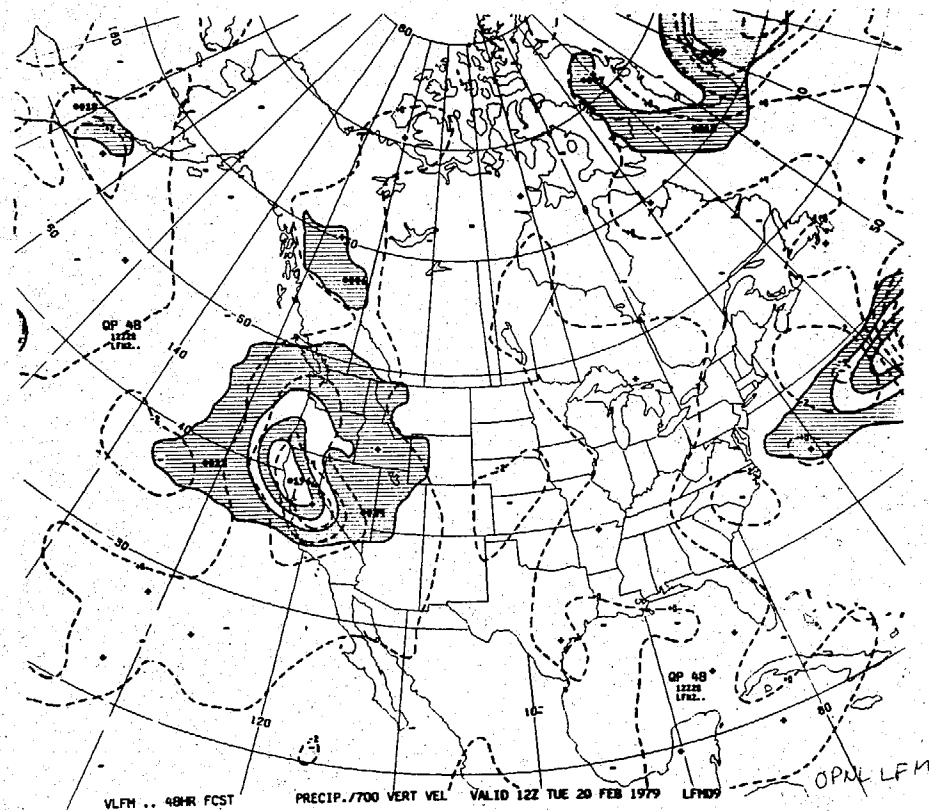


FIG 5G



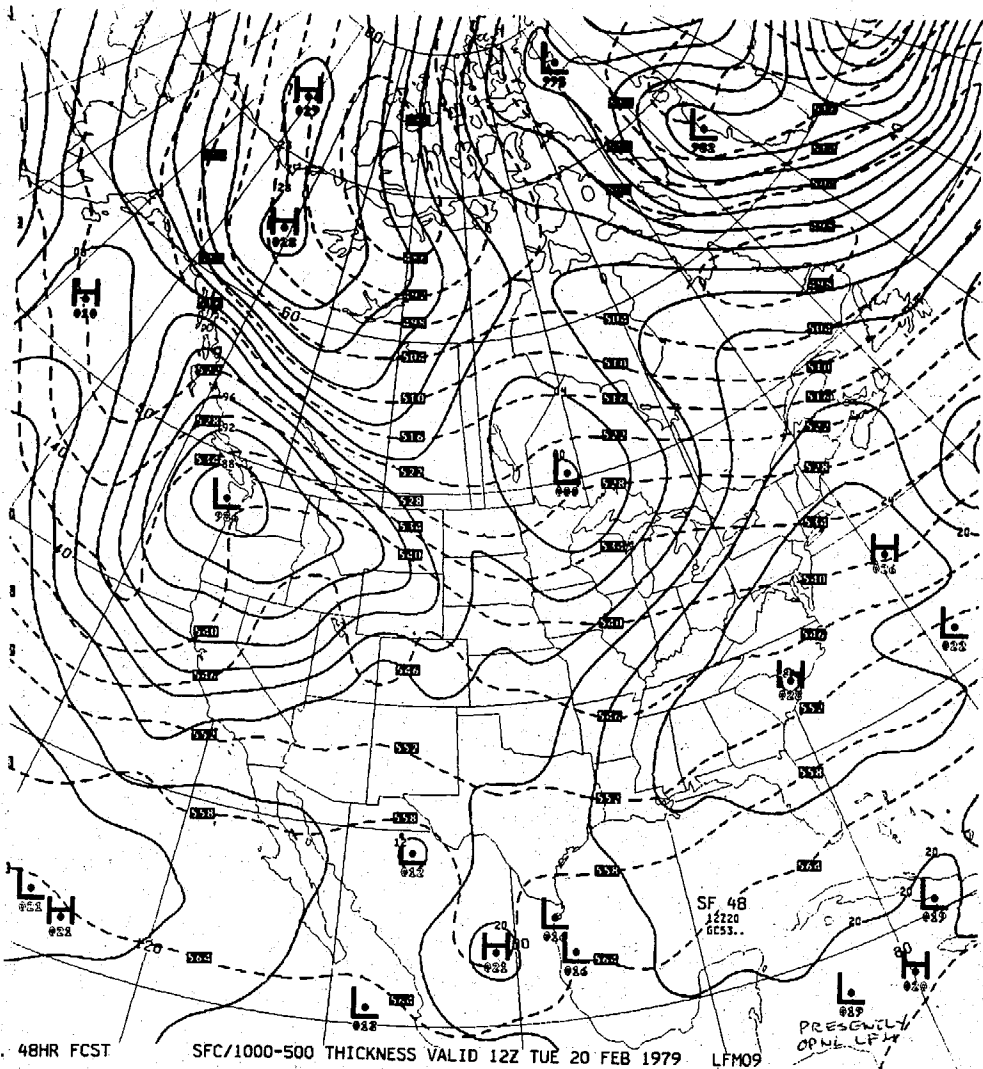
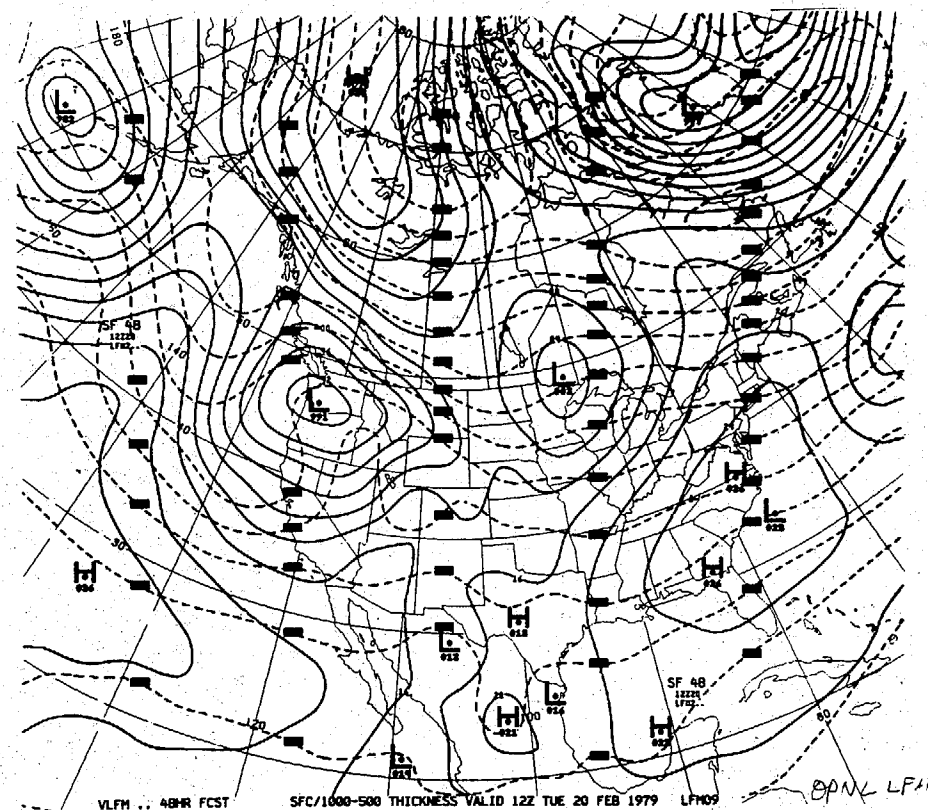


Fig 54



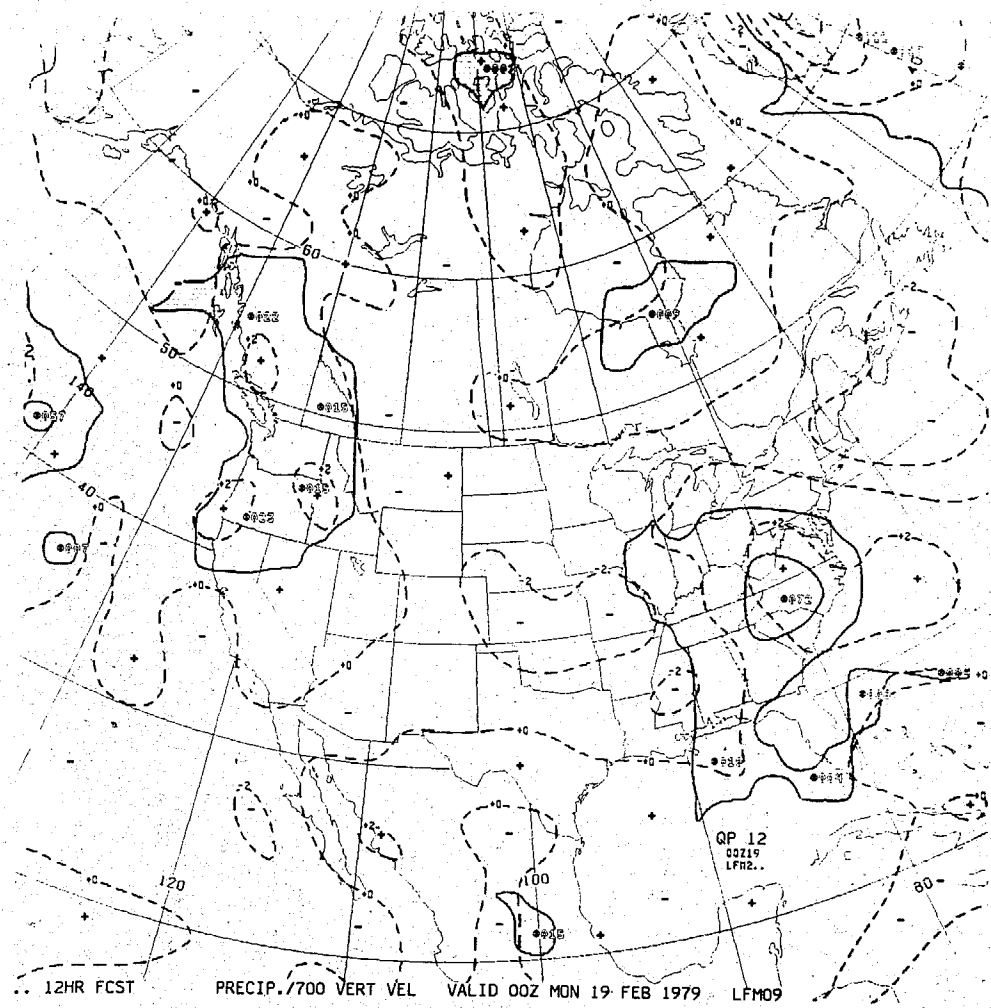
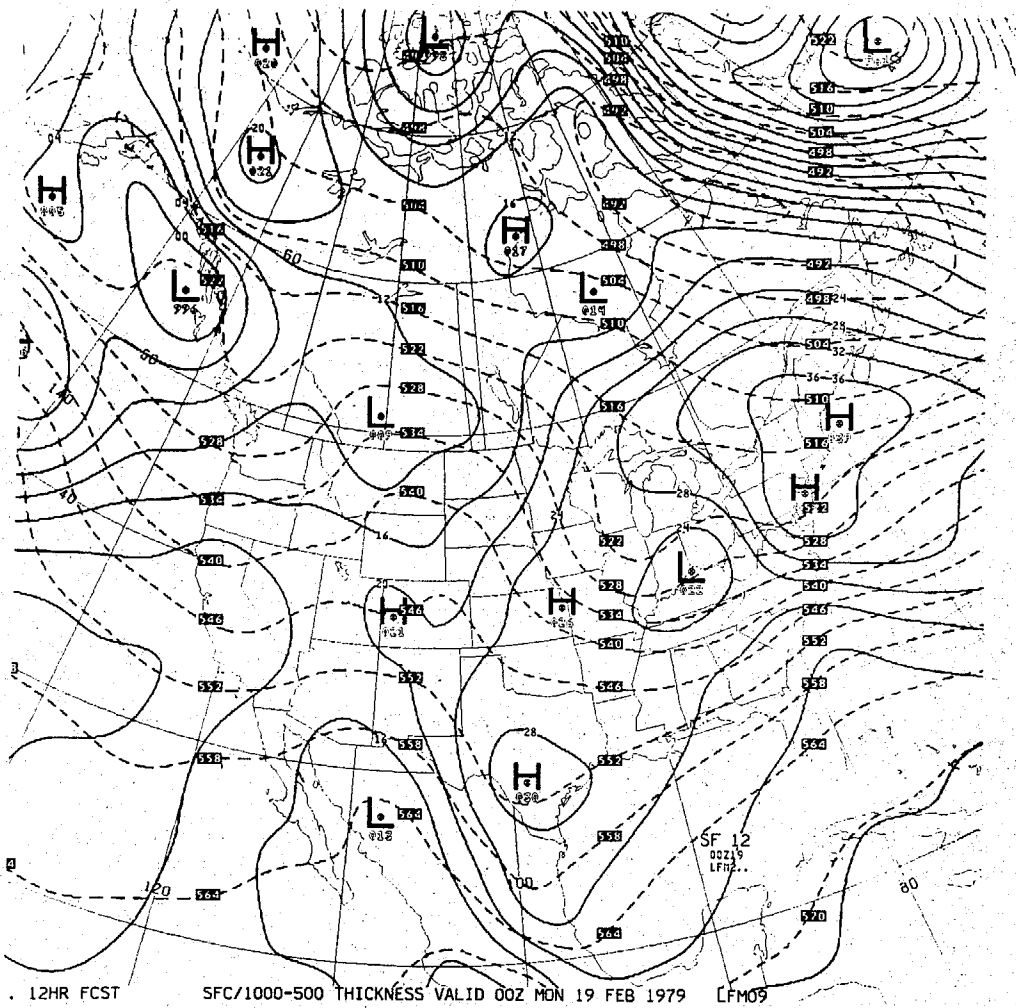


Fig 6A

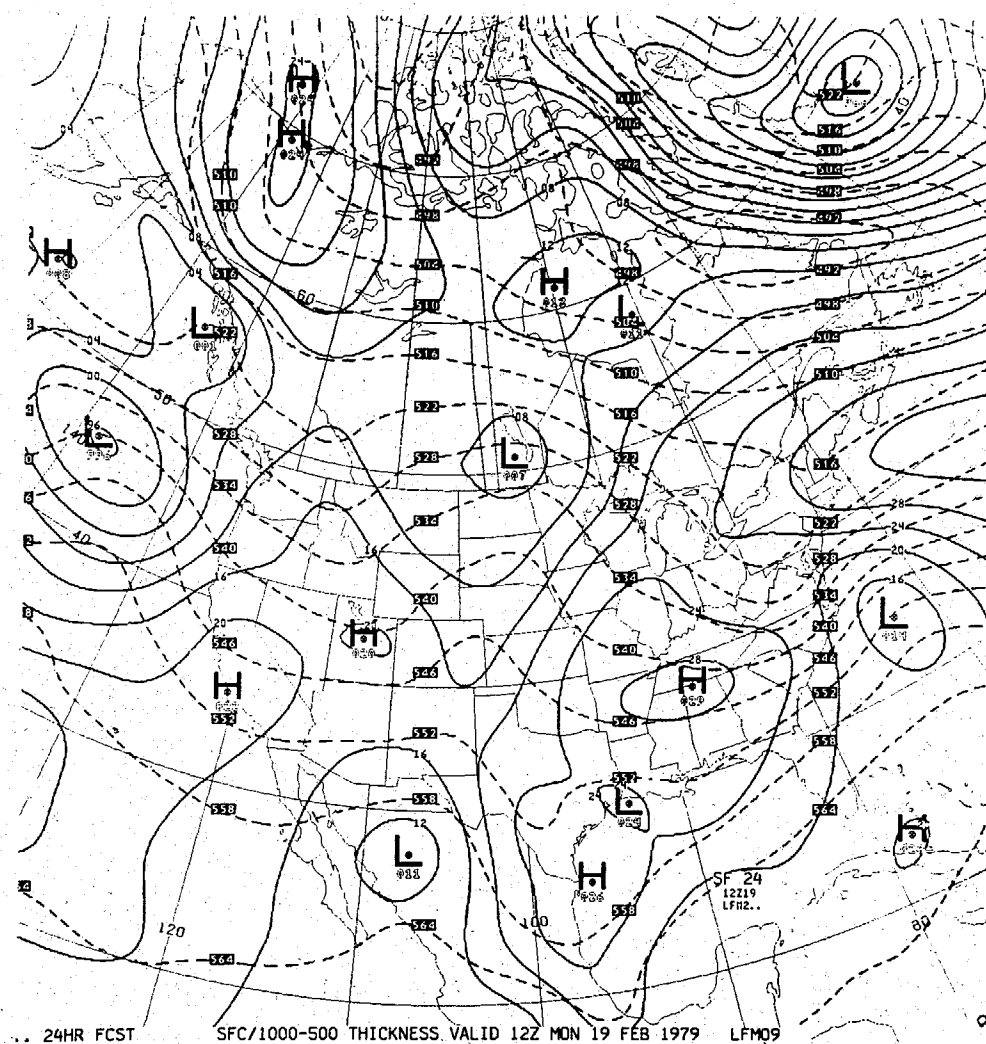
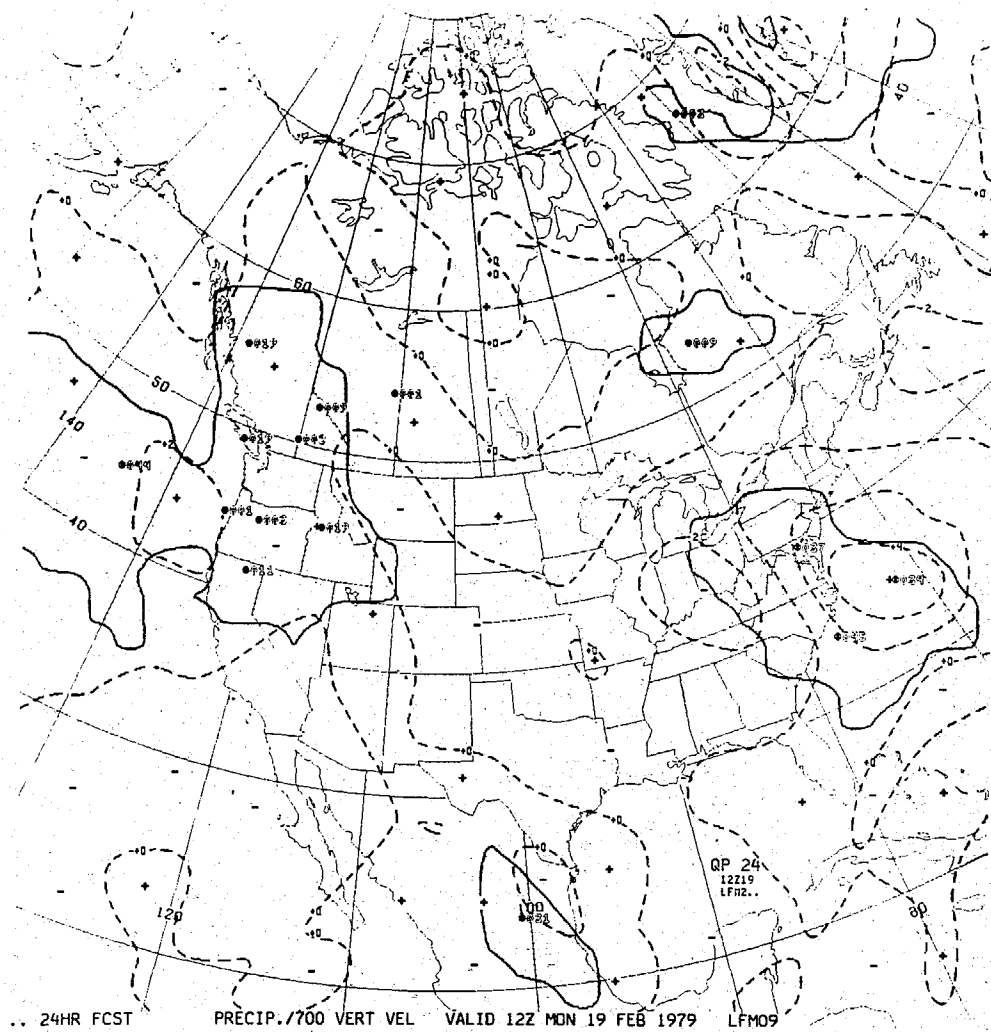
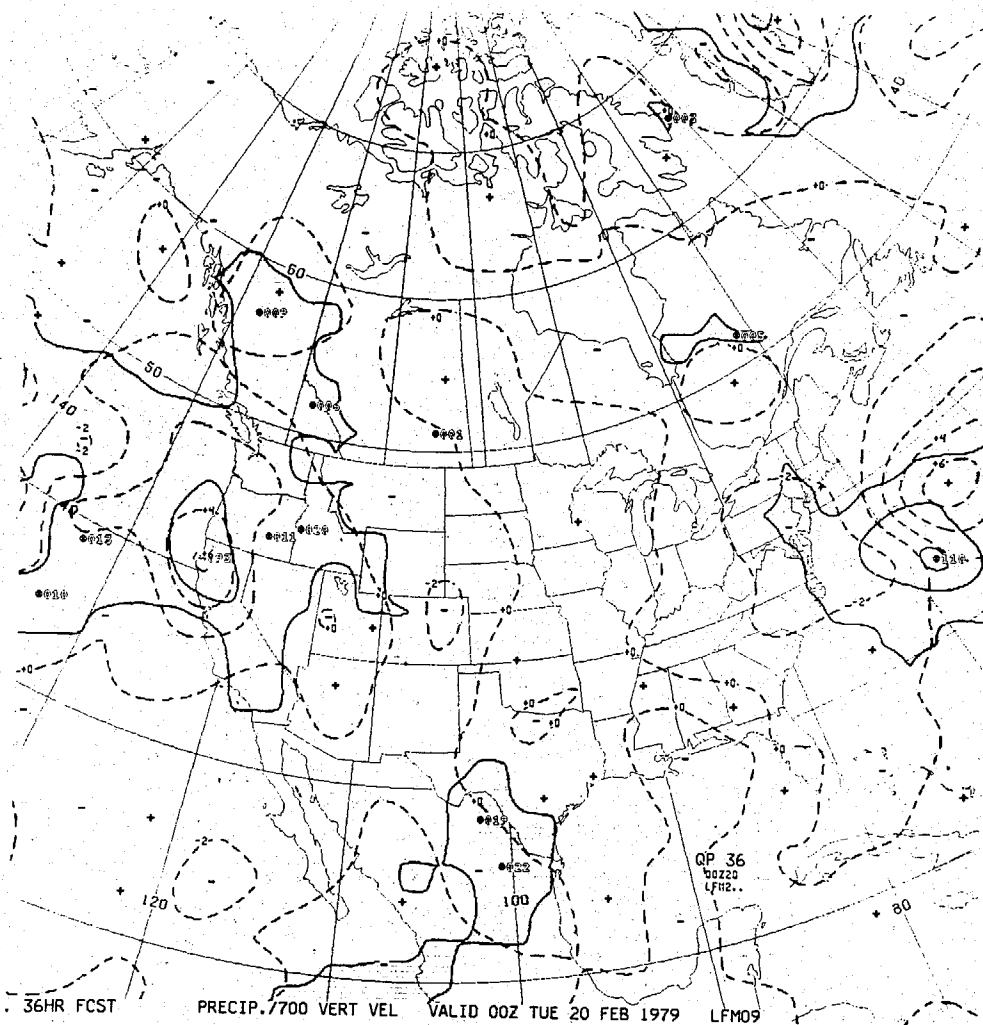
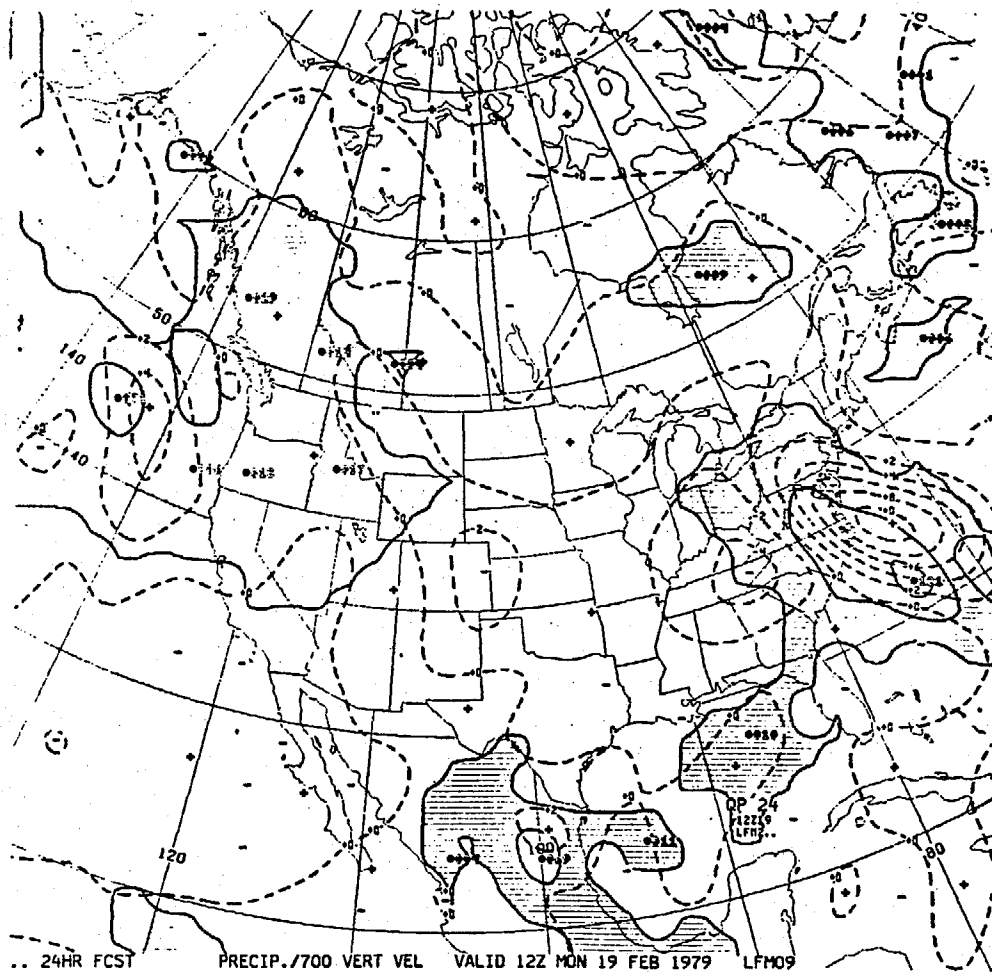


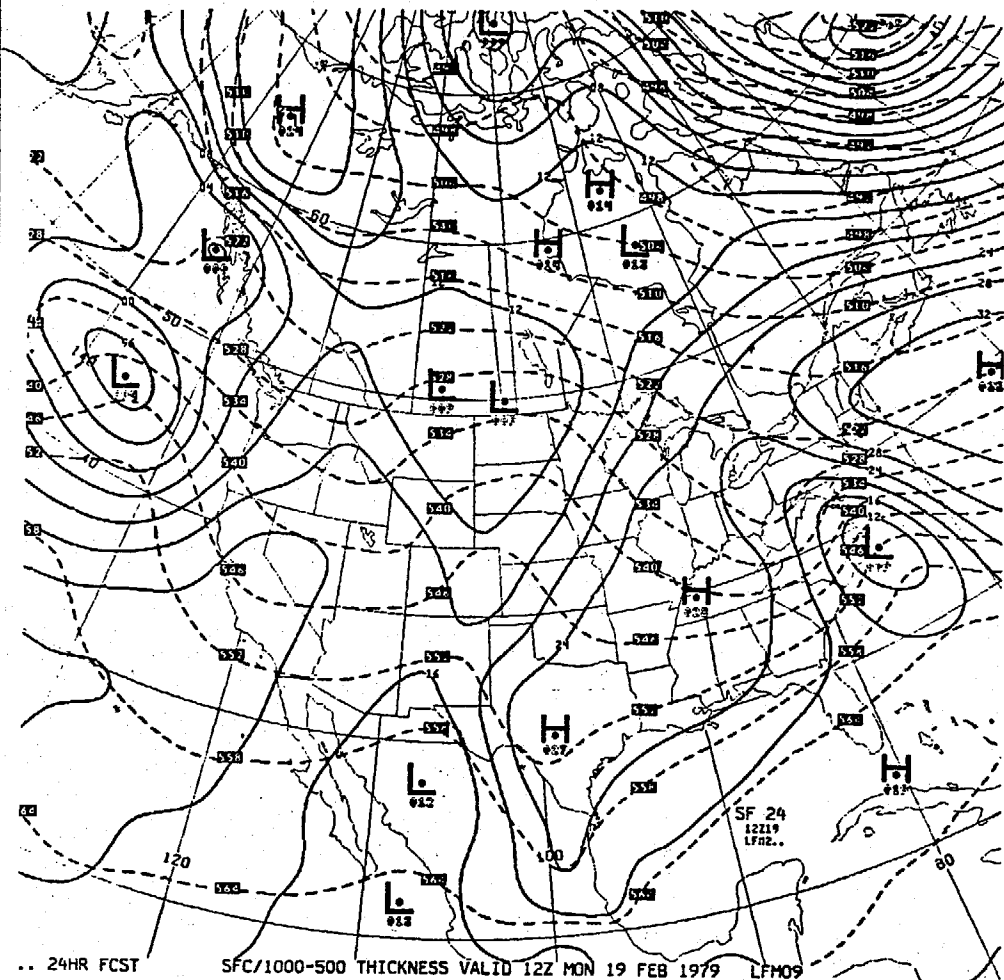
Fig 6B



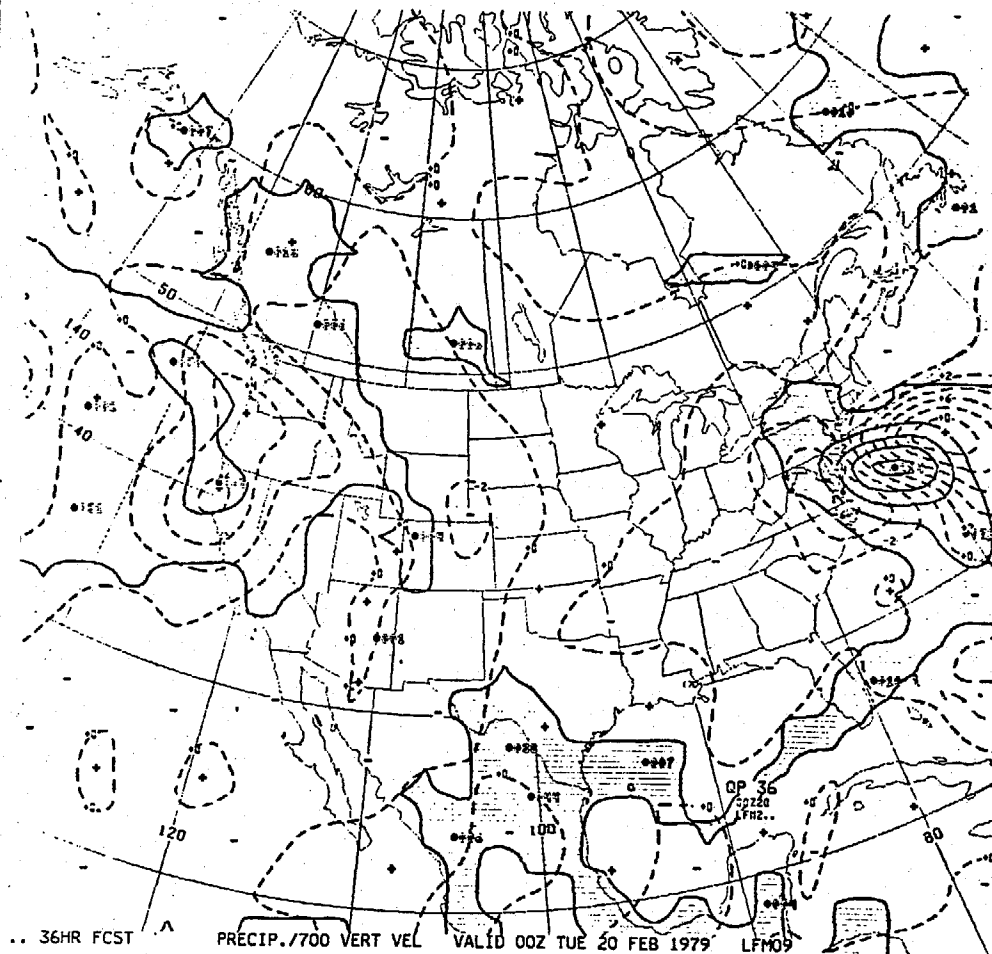


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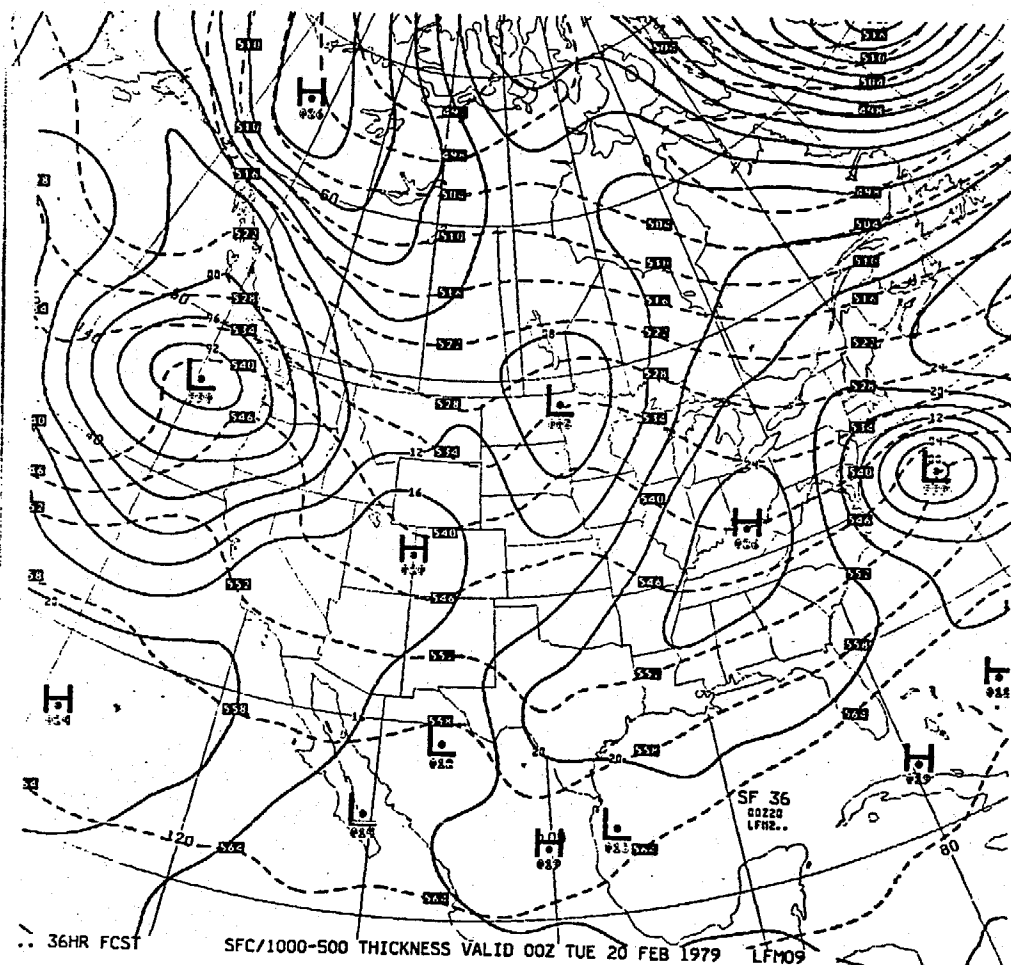
FIG 7A



~~171608Z 1979~~



~~FIG 7B~~



~~FIG 7B~~

FIG 7B

resolution. This result suggests that the forecast is not very sensitive to the sea-surface temperature, convection formulation or to horizontal resolution.

#### Ten Layer Version of the LFM

Newell (1981) presented results obtained with a ten layer version of the LFM II model. Those experiments were conducted to evaluate the impact of air-sea interactions on the model forecasts. Very recently, Collins et al. (1981) presented their results of an intercomparison of several regional forecast models, including the ten layer version of the LFM II. Except for some problems with warm season convective precipitation, the ten layer LFM II performed as well or better than all other models tested.

This ten layer version of the LFM has tropospheric vertical resolution of about 120 mbs and stratospheric resolution of about 70 mbs. It also includes a 50 mb surface boundary layer. The horizontal resolution is 127 km at 60°N latitude on the polar stereographic map. The model incorporates all the physical processes contained in the presently operational LFM, including a bulk aerodynamic estimate of evaporation from the sea.

Figure 7 shows the 24 and 36 hr forecasts of 12-hourly precipitation and mean sea level pressure produced by the ten-layer model. The predicted position of the storm at 1200 GMT 19 Feb. 79 agrees with Bosart's analysis of the storm's position at 0900 GMT 19 Feb 79, although the forecast storm is to the east of Bosart's position and is about 3 mb deeper. The predicted precipitation (isoplethed at intervals of 1/2 inch) agrees quite well with Bosart's analysis.

It seems clear that the increased vertical resolution of the model permitted the achievement of a much more accurate forecast of this storm.

## Conclusions

From the results presented here, it seems evident that for certain types of storms greater vertical resolution is required in NMC's operational regional forecast models.

We could show no direct evidence that more accurate sea surface temperature analyses are necessary, but since the impact of air-sea interactions on model forecasts was conclusively shown by Newell (1981), it is obvious that reasonably accurate sea surface and atmospheric temperature analysis are essential for predicting east-coastal cyclogenesis. We ought to repeat this forecast using more accurate sea surface temperatures.

The details of the coastal frontogenesis and the impact of convection are difficult to document in forecasts produced with models developed for operational use. It seems that additional progress in operational model development will require the construction of versions of the operational model that lend themselves to detailed diagnosis. To do this effectively NMC will need to significantly enhance its computer graphics capability for use in research and development.

At NMC we are planning continued development of high resolution models for operational use; and in addition we are emphasizing the development of improved objective-analysis systems. The implementation of these new methods is dependent upon NOAA's acquisition of an augmented computational facility. It is our expectation that a President's Day storm in 1983, should it occur, will be predicted with a precision far surpassing the result achieved in 1979.

## References

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